

ENGINEERING  
TOMORROW

*Danfoss*

eBook | Hydronic Intelligence™

# Green cities say HI!

Hydronic Intelligence™ (or HI!™) by Danfoss is an innovative approach to heating and cooling systems in residential and commercial buildings as well as district energy. It seamlessly integrates smart technology and advanced controls to optimize energy efficiency and user comfort. Using intelligent algorithms and precise monitoring, Hydronic Intelligence™ ensures dynamic adaption to changing conditions, reducing energy waste and enhancing overall performance.

**START HERE** >

HI!

# Markets are changing

## Current challenges bring new opportunities

### ➔ Heat Pumps are rapidly replacing oil and gas

The EU has set a target of installing 60 million more heat pumps by 2030. The transition to heat pumps is leading to an increase in low-temperature systems.

- How can we ensure the operational efficiency aligns with their specified performance?

### ➔ Energy Renovation is accelerating

The European Commission's **Energy Performance of Buildings Directive (EPBD)**, designed to boost buildings' energy performance to reach the goals defined in the European Green Deal, includes guidelines on installing self-regulating devices, dynamic hydronic balancing and indoor environmental quality.

- How can we minimize buildings' energy consumption while providing optimal comfort for its occupants?

### ➔ Sustainability needs to be embedded in all products

9 out of the UN's 17 Sustainable Development Goals (SDGs) apply to buildings. The revised EU Energy Efficiency Directive (EED) includes requirements for prioritizing energy efficiency measures for energy poor households and enshrining final customers' rights to heating, cooling and hot water.

- How can we ensure energy is utilized precisely when and where it is needed?

### ➔ Digitalization is creating new opportunities

By 2025, 75 billion devices are expected to be connected to the Internet. As we move towards renewable energies and other alternative heat sources, the energy supply will be increasingly decentralized and variable. Digitalization is key to connecting these diverse energy sources with demand.

- How can we integrate digital data effectively in order to optimize both energy generation and consumption?

### ➔ End-to-end solutions are key to improving efficiency

Meeting energy efficiency targets requires optimizing energy creation, transport and consumption, from each energy supply source to the district heating system to the buildings that use the energy produced.

- How can we establish a holistic perspective and shift away from siloed thinking throughout the entire energy chain?

### ➔ District energy as sustainable alternative to individual heat sources

District heating grids are increasingly integrated with renewable sources such as heat pumps, geothermal and surplus heat from e.g. data centers.

- How can we ensure reliable operation and manage peak load conditions?





# How Hydronic Intelligence™ Turns Challenges into Opportunities

We believe Hydronic Intelligence™ is the key to turning market challenges into opportunities for increased energy efficiency. In this publication, we'll demonstrate how we can use Hydronic Intelligence™ to:

➔ **Optimize heat pumps and low-temperature systems.**

Dynamic hydronic balancing ensures the best 'low-temperature heating' necessary for elevated heat pump performance.

➔ **Provide a cost-efficient way of renovating existing buildings.**

The total potential savings from optimizing hydronic distribution in domestic EU heating systems would amount to 22.6 Mtoe. This can be done using existing technology, with a minimal upfront investment and short payback time.

➔ **Improve energy efficiency.**

The EU considers dynamic hydronic balancing to be a "quick win" in terms of improving buildings' energy efficiency. Conservative estimates indicate that building owners can save 10% on the final energy bill in a multi-family building with a payback time of one year. Hydronic Intelligence offers the next level in energy efficiency by optimizing both energy production and distribution, which will lead to further energy efficiency gains.

➔ **Use digitalization to enable smart building management.**

Using Hydronic Intelligence™, we can further optimize energy efficiency using data on actual demand, external conditions and system performance.

➔ **Offer end-to-end heating and cooling system optimization.**

By digitally connecting the supply and demand side of the energy equation, we can make our buildings even more energy efficient.

➔ **Manage constant and efficient heating supply**

Despite temperature fluctuations and changes in demand, district heating networks and sub-stations can be optimized remotely to ensure most efficient system delta T.



SECTION 1

SECTION 2

SECTION 3

SECTION 4



## Where we are now

Find out how hydronic balancing, control and connectivity are already improving energy efficiency

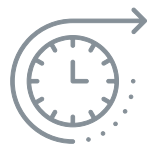
[Read more →](#)



## How we achieve accurate temperature control

See how existing technology can accurately control temperature

[Read more →](#)



## How HI! MachineS™ will shape our future

Learn how new technology will optimize our future heating and cooling systems

[Read more →](#)



## Conclusion

[Read more →](#)



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# Increasing energy efficiency in commercial buildings with hydronic balancing, control and connectivity

## Challenge

For the heating and cooling systems to operate as effectively and efficiently as possible, they need to be hydraulically balanced. However, manual balancing using standard control valves is a time-consuming process, and the heating system can easily become unbalanced as load conditions change.

## Solution

More than 20 years ago, Danfoss pioneered an approach for dynamic hydronic balancing. We introduced Pressure Independent Control Valves (PICV) that automatically optimize water flow in the heating and/or cooling system and eliminate hot and cold spots. In 2015, we took automatic hydronic balancing one step further when we introduced digital IoT actuators. Now, building managers can utilize actual system data in their Building Management Systems to remotely monitor and manage the HVAC system's performance.

## Results

- ➔ **10-15%** energy savings per building
- ➔ **Precise temperature control** throughout the building
- ➔ Building managers can **make informed decisions** on energy optimization, maintenance and future upgrades







# Using dynamic hydronic balancing to **increase comfort and energy efficiency** in single family homes

## ● Challenge

With rising energy prices, homeowners are looking for ways to improve energy efficiency, without sacrificing comfort. However, to make the most of their heating system, they need more accurate temperature control and uniform room heating.

## ● Solution

Danfoss has various solutions to help homeowners increase energy efficiency by hydronically balancing their radiator or underfloor heating system. Mechanical and Electronic radiator thermostats (mTRV and eTRV) ensure that each radiator receives the exact amount of hot water to keep each room at the desired temperature. TRVs limit the flow through each radiator by regulating the room temperature to the desired level, which lowers the return water temperature and helps the heating source, for example a condensing boiler, operate more efficiently. And the Danfoss Icon2™ zone-control system for floor heating and other applications with actuators, uses automatic hydronic balancing to ensure all rooms in the home make the most of the energy available.

## ● Results

➔ **11-22%** reduction  
in energy consumption

➔ Payback time of less than  
**18 months**





# Using digital connectivity to **optimize heating and domestic hot water distribution** in multi-family buildings

## ● Challenge

One of the challenges with heating multi-family buildings is striking the right balance between energy costs and efficiency, and resident comfort. Building occupants need a reliable heating system that also delivers domestic hot water quickly. At the same time, building owners need tools that can help them manage and optimize each building's energy system.

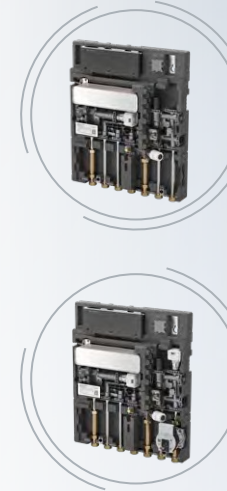
## ● Solution

Dynamic hydronic balancing helps regulate hot water and water used for heating, so the right amount of water is available at the right place and time. Thus, dynamic hydronic balancing plays a crucial role in Danfoss' digital Flat station solution – the EvoFlat 4.0 PRO. EvoFlat is designed to prioritize domestic hot water over heating. Its electronic by-pass and circulation function use schedules and intervals to make sure hot water is instantly available when needed and saved when it isn't.

To give building owners the connectivity they require, the EvoFlat 4.0 PRO can be seamlessly integrated with building management systems to enable remote monitoring and troubleshooting. Its intelligent controller adapts to external conditions to provide the exact temperature needed to keep residents comfortable and protect the building. The system can automatically regulate the building's temperature based on weather conditions, indoor climate or energy prices.

## ● Results

- ➔ **10-40%** energy savings through dynamic, automatic temperature control
- ➔ Instantaneous domestic hot water **improves tenant comfort**







# Digitalization takes heating and cooling optimization one step further

## Challenge

Traditional heating systems fail to adjust to changing weather or the thermodynamic properties of the building. This results in overheating and poor indoor conditions. At the same time, heating systems in up to 75% of multi-family buildings are inadequately balanced.

## Solution

Installed sensors in apartments enable Leanheat® Building's artificial intelligence to learn the building's thermodynamic behavior and to optimally control the HVAC system. Heating is always optimized regardless of changes in weather or in the building's properties, which change as it ages. Together with proactive fine-tunings Leanheat® Building provides permanent energy efficiency to all multi-family buildings.

## Results

- ➔ **6-10%** energy savings per building
- ➔ **Remote access and control reduce time** spent on service and maintenance





# How we achieve accurate temperature control



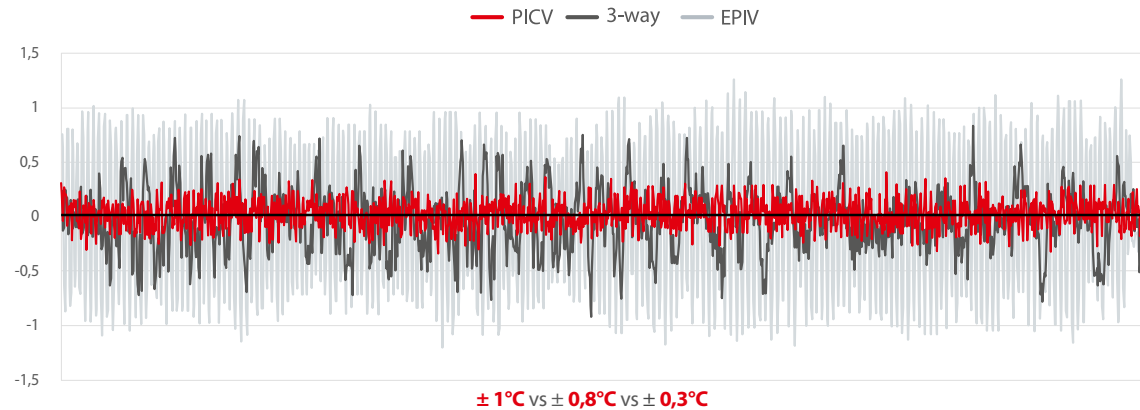
In Section 1, we looked at how dynamic hydronic balancing is helping improve energy efficiency and occupant comfort in commercial, single- and multi-family buildings. Key to this development is the ability to accurately control a room's temperature. In this section, we'll examine which technology enables the most accurate temperature control.





# Achieving **accurate temperature control** in air handling units (AHUs)

## ● Temperature control accuracy comparison



## ● Using PICV technology achieves the most accurate temperature control

When it comes to HVAC systems, precision is paramount. The choice of control valve technology can significantly impact temperature accuracy. To identify the solution that would produce the most accurate temperature, the Danfoss team conducted a test at Danfoss' offices in Ljubljana, Slovenia. The team equipped the production and logistic area's AHU with three different control solutions: PICV (red), ePIV (light gray) and 3-way control valves (dark gray). Over a period of several months, the team used all three solutions. Throughout the entire study period, they measured the flow and temperatures in different places. The graph shows the average results over comparable periods of time. Using PICV technology enabled the team to achieve a temperature accuracy of just 0.3°C, far above the industry standard.

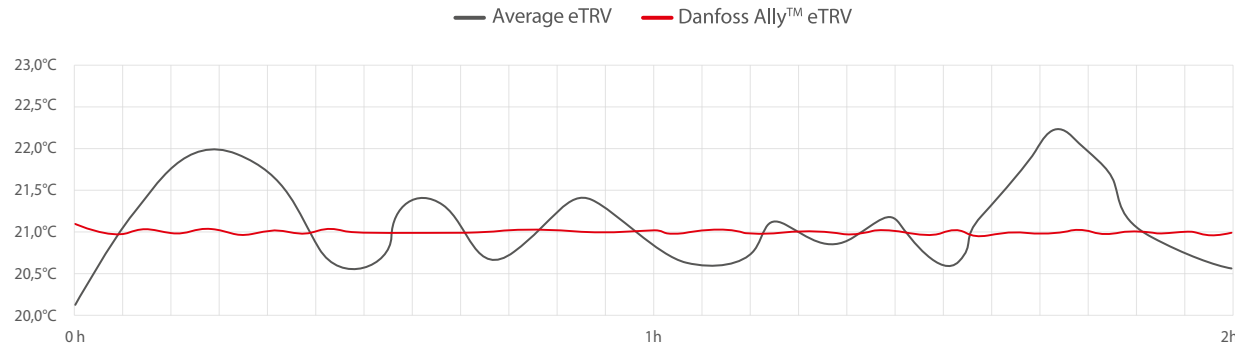
Download the  
whitepaper PDF





# The best Control Accuracy on the market

● Control accuracy (CA) – eTRV – Average vs Danfoss Ally™



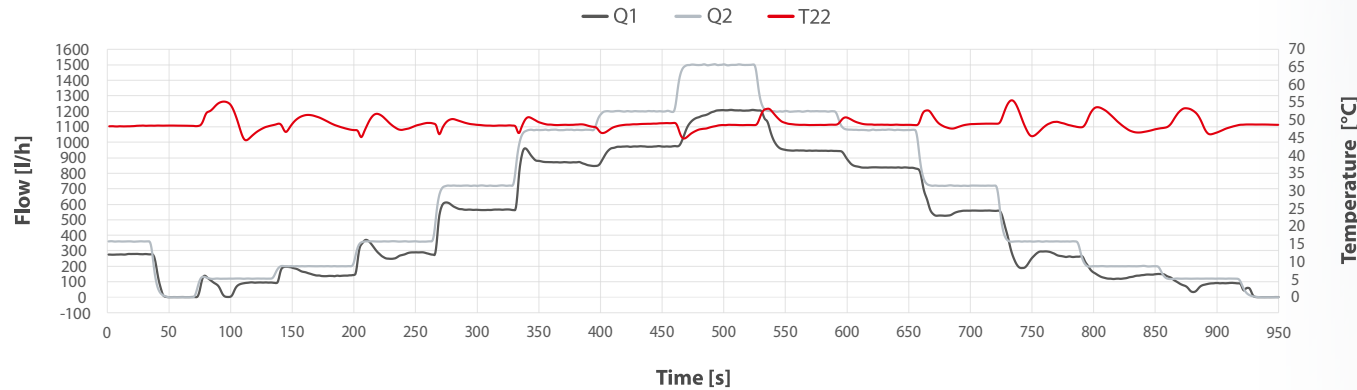
● In April 2021, the EN215 standard put in place new legislative demands for energy performance. The standard contains a control accuracy (CA) classification, which determines the regulation precision of a thermostatic radiator valve. The lower the CA value, the more dependent the valve is on air temperature as opposed to water temperature, thus giving a more accurate measurement of the actual room temperature. Danfoss thermostats are EN215 approved and achieve the highest ranking possible – 0.2 K.

As can be seen from the red colored line in the graph above, this accuracy is the highest on the market.

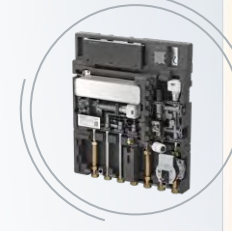
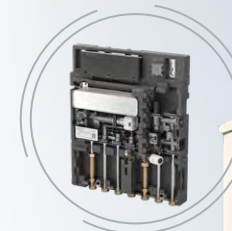


# Domestic hot water temperature control in Flat stations / Heat Interface Units (HIUs)

● Control performance comparison 6-hour zoom-in

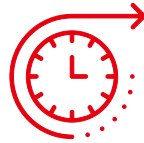


● Accurate temperature control in domestic hot water applications is crucial for ensuring comfort, safety, and efficiency. As the red line in the graph demonstrates, the Danfoss EvoFlat 4.0 provides exceptionally accurate and stable temperature control, ensuring that a building's domestic hot water supply remains at the desired temperature. The red line shows the measured hot water temperature. With EvoFlat 4.0, the temperature level remains stable, even during high-volume tapping periods as can be seen in the middle of the graph where the gray lines Q1 and Q2 show respectively the primary side flow and secondary side flow.





# How HI! MachineS™ will shape our future



While the use of Hydronic Intelligence™ products and solutions already paves the path for increased energy efficiency and decarbonization in buildings, we believe we can take this technology even further.

Where these innovative products and solutions enable specific heating and cooling applications to perform better, we are in progress of developing new technologies that unite source applications with energy distribution and/or consumption applications.

These upcoming technologies, **HI! MachineS™**, further increase energy efficiency by optimizing the combination of one or more demand side applications with an energy supply side application. The use of digital data, Artificial Intelligence (AI) and best-in-class software solutions help to make this happen.

In this section, we showcase some of the HI! MachineS™ we're working on.





# Chiller ⇔ Terminal units

## HI! MachineS™ example

In this example of HI! MachineS™, we can digitally connect the chiller to room temperature data. This will enable building managers to dynamically adjust the chiller's supply temperature based on weather forecasts and each room's current energy needs. This offers several advantages:

### ● Energy Efficiency:

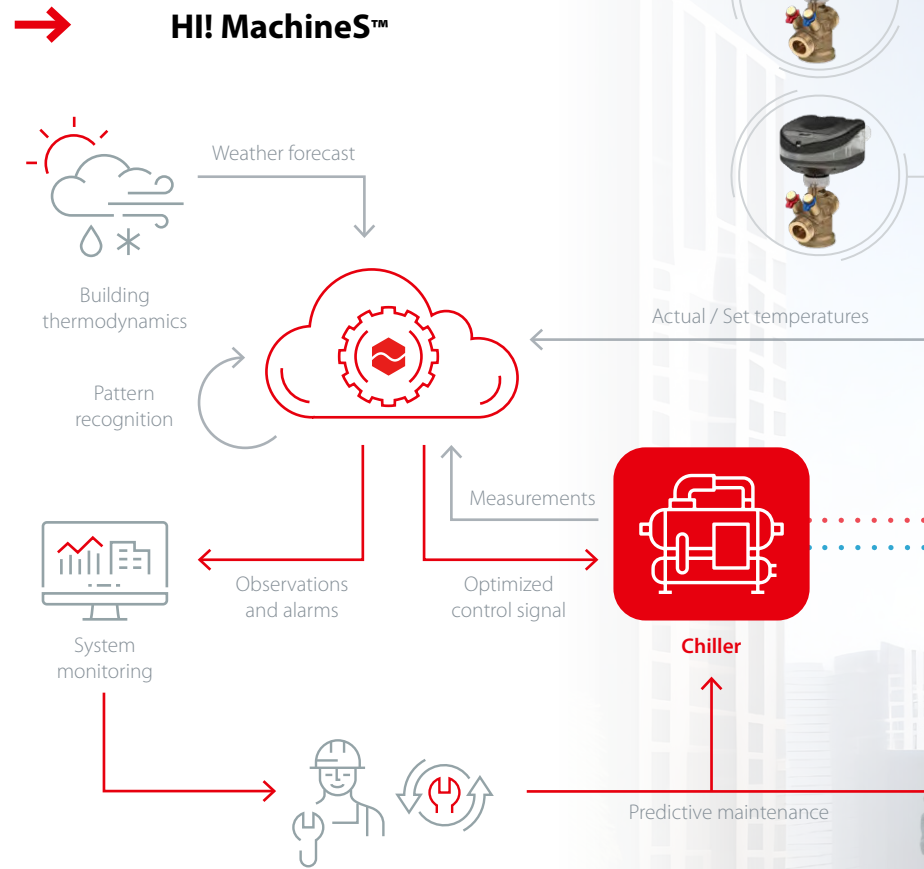
Stability in the system contributes to energy efficiency. Chillers and heat pumps, in particular, benefit from a stable load. By monitoring the individual room demand it is possible to create a more stable demand on the system, which will lead to higher efficiency.

### ● Environmental Impact:

An ITG study on dynamic hydronic balancing in hotels showed that payback times between 1.6 and 4.4 years are possible and that implementing dynamic balancing in all hotels in Germany could save 24.2 m kWh/y, which is equivalent to 7,480 t CO<sub>2</sub>. The potential with HI! MachineS™ technology would be even greater.

### ● Improved Comfort:

Dynamic supply temperature adjustments ensure that the indoor environment remains comfortable and consistent. Occupants are less likely to experience temperature fluctuations, providing a better overall experience and enhancing productivity in commercial spaces.







# Heat pump ⇔ Hydronic underfloor heating

## HI! MachineS™ example

Single-family buildings can benefit from HI! MachineS™ by integrating heat pump and room temperature data. This enables homeowners to dynamically regulate the heat pump's supply temperature, based on each room's real-time demand and weather forecasts. Consider the following advantages:

### ● Energy Optimization:

By using Danfoss' Icon2™ we can optimize the heat pump to match the actual demand for heating in a single family house. In combination with the automatic hydronic balancing of the different circuits, energy savings up to 15% can be expected.

### ● Financial Savings:

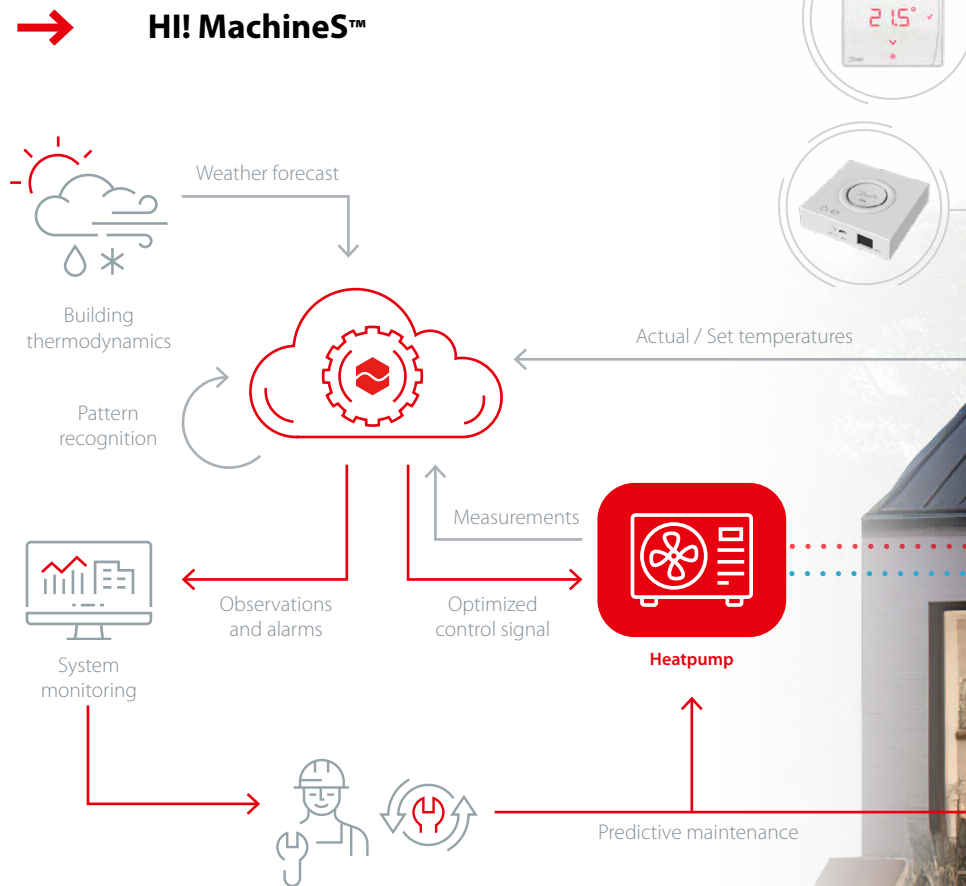
Lower energy consumption results in reduced home owners' expenses.

### ● Load Management:

The system can anticipate shifts in demand due to factors like room occupancy, weather variations, or time of day, allowing it to tailor supply temperatures for optimal efficiency.

### ● Enhanced Room Comfort:

By adjusting supply temperature dynamically, HI! MachineS™ ensures stable and comfortable indoor conditions, eliminating temperature fluctuations and improving occupant well-being.





# Substation ⇔ Radiator heating

## HI! MachineS™ example

In multi-family buildings, you can have HI! MachineS™ by using Leanheat® Building, Danfoss' modern SCADA solution, applied on the building's district heating substation. By combining this with our dynamic hydronic balancing and control solutions, such as ASV in combination with RA-N or RA-DV, you can achieve a wide range of benefits:

### ● Energy Efficiency:

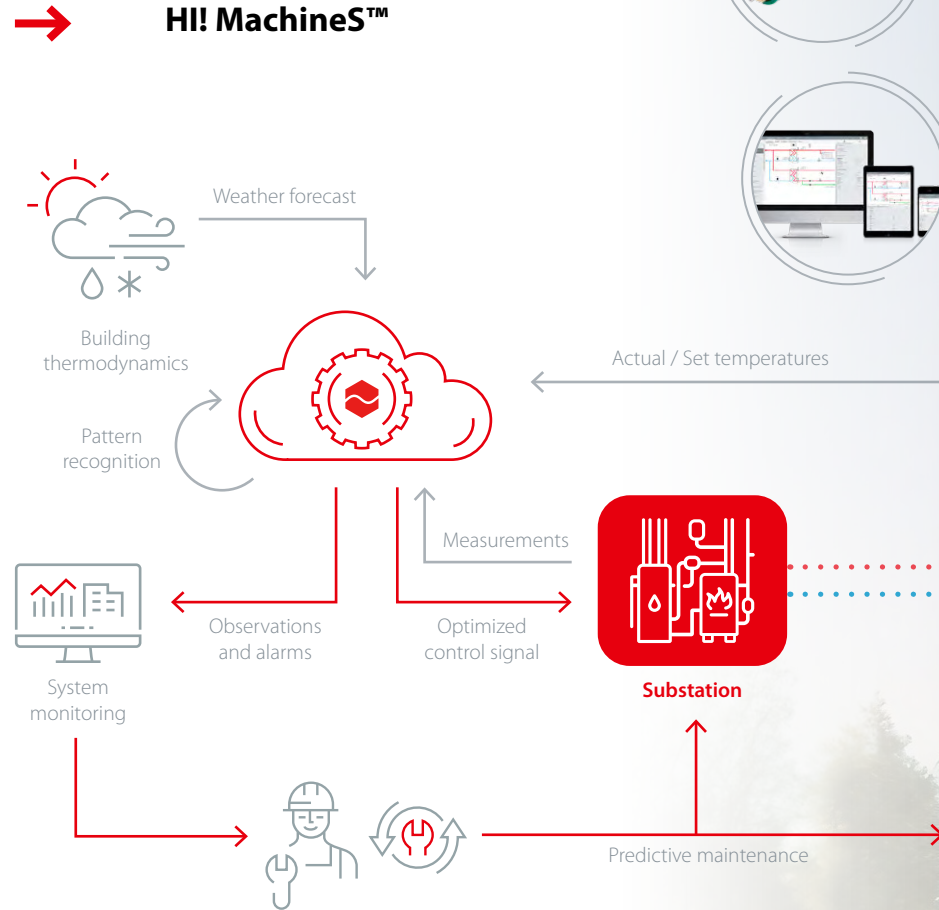
Leanheat® Building advanced algorithms continuously analyze and adjust the heating system based on real-time demand, optimizing energy distribution from the substation. By combining this AI solution with dynamic hydronic balancing and control solutions such as Danfoss ASV with RA-N pre-setting valves, or RA-DV dynamic valves, precise flows throughout the radiator heating system are ensured and energy waste is minimized.

### ● Comfort and Consistency:

The integrated system guarantees stable and consistent indoor temperatures by dynamically controlling the heat distribution. Residents in multi-family buildings benefit from a comfortable living environment with minimal temperature fluctuations, enhancing overall satisfaction.

### ● Hydronic System Optimization:

Danfoss' dynamic hydronic balancing and control solutions ensure the hydronic system's precise balance, resulting in efficient and effective heat distribution in full- and partial load conditions.





## Conclusion

# Partner with Danfoss to decarbonize our buildings and cities

- **Hydronic Intelligence™ already makes our buildings more energy efficient.**

Whether it's single- and multi-family homes or commercial buildings, dynamic hydronic balancing and other innovative solutions help homeowners and building managers make the most of available energy.

- **Digital connectivity adds an extra layer of control on the demand side.**

Using digital connectivity solutions like Ally™ and Leanheat®, our modern SCADA solution, homeowners and building managers can connect usage data with external factors to set the optimal temperature for any given situation.

- **The next step is HI! MachineS™**

HI! MachineS™ supports the development of greener cities. By connecting energy demand and supply to each other we enable concrete solutions living up to our motto “the greenest energy is the energy we don't use”. We want to be your preferred decarbonization partner and are ready to help you on your journey towards carbon neutrality.





Let's start the dialogue at  
**#GreenCitiesSayHi**

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At Danfoss, we have over 90 years of expertise in creating energy-efficient heating and cooling solutions for buildings. We invented the radiator thermostat and the automatic differential pressure controller – two of the main components in our automatic balancing solutions for two-pipe heating systems in buildings. And we're already pioneering ways of using AI and digital twin technology to help buildings use energy more efficiently. We believe Hydronic Intelligence™ with HI! MachineS™ technology is the logical next step on the road to greener communities. We look forward to working with you, our partners, to make this a reality.

**Anton Koller**, President,  
Danfoss Climate Solutions –  
HydronicS division

”

**Danfoss A/S**  
Climate Solutions . danfoss.com . +45 7488 2222

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